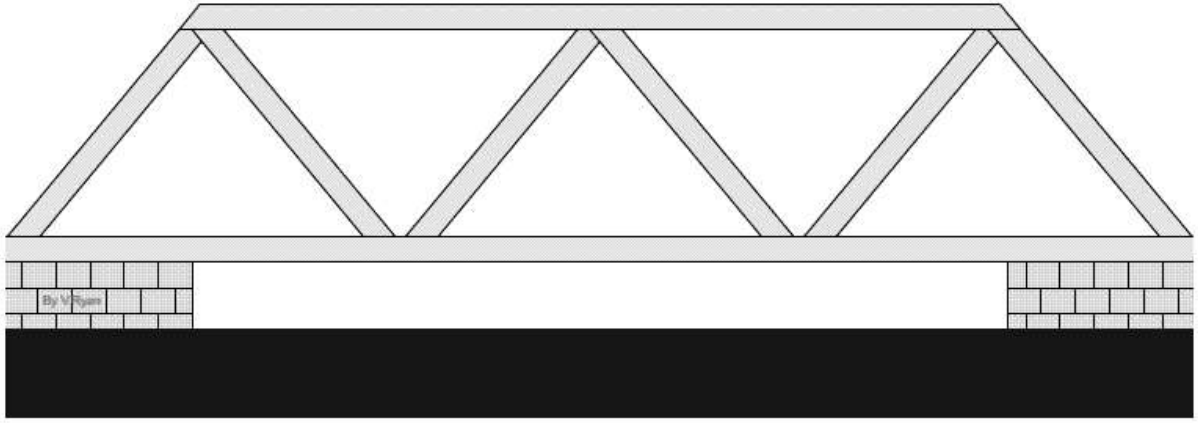
What is Motion?

Motion is a phenomenon where an object changes position with time.

In a civil engineering context, motion can be used in **railway, bridges, roads, marine and also runway problems and designs**.



Types of Motion

- Motion in a straight line - Horizontal
- Vertical Motion
- Curve Motion - Projectiles

Terms

Speed, Velocity, Displacement & Acceleration

Speed is a scalar quantity defined as the rate of motion but without any information of the direction of travel.

$$speed = \frac{distance}{time} = \frac{m}{s}$$

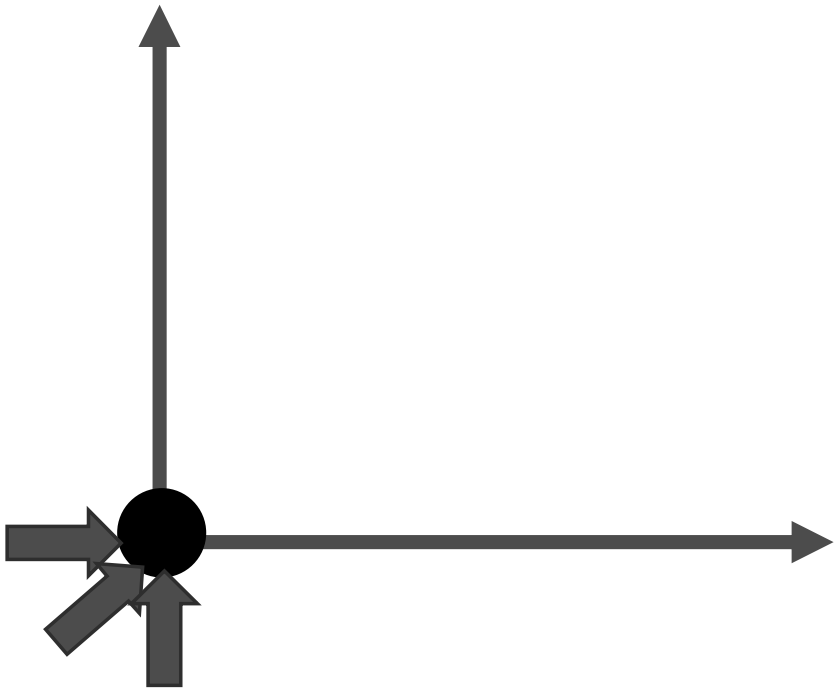
Velocity is a vector quantity defined as the rate of change of motion in a specific direction.

$$\bar{v} = \frac{Displacement}{Time\ interval} = \frac{\Delta x}{\Delta t} = \frac{m}{s}$$

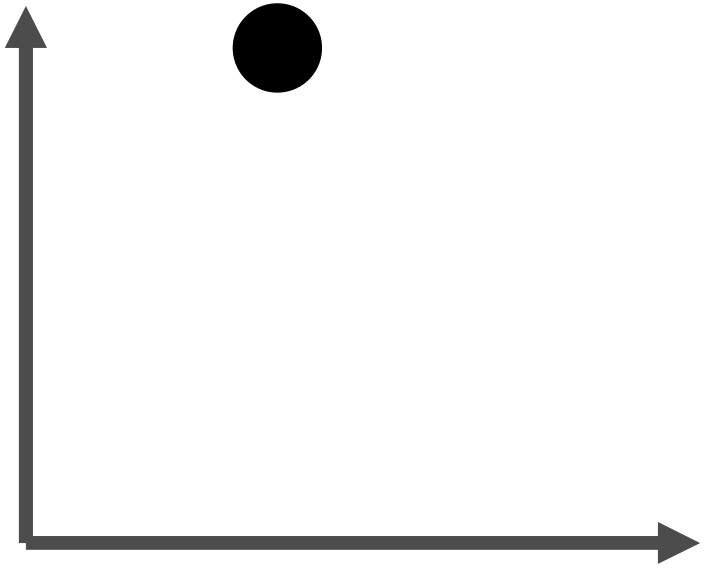
Acceleration is a vector quantity defined as the change in velocity over the change in time.

$$\bar{a} = \frac{change\ in\ velocity}{change\ in\ time} = \frac{\Delta v}{\Delta t} = \frac{ms^{-1}}{s}$$

Acceleration can occur in two ways:



A particle will accelerate under the action of a resultant force. For example a car will accelerate under the action of the force from the engine.



A particle in free fall (with no drag force) will have an acceleration equal to the acceleration of gravity. For example an apple falling from a tree.

There are five traditional equations of motion. These equations are also called the **SUVAT** equations.

***s* for Displacement**

***u* for initial velocity**

***v* for final velocity**

***a* for acceleration**

***t* for time**

$$s = \left(\frac{u+v}{2}\right).t$$

$$s = ut + \frac{1}{2}at^2$$

$$s = vt - \frac{1}{2}at^2$$

$$v = u + at$$

$$v^2 = u^2 + 2as$$

***s* for Displacement (*m*)**

***u* for initial velocity (*m/s*)**

***v* for final velocity (*m/s*)**

***a* for acceleration (m/s^2)**

***t* for time (*s*)**

All measurements should be in their base S.I units before substituting them into any formula.

Note that the quantities s, u, v and a are all vector quantities, hence their sign represents direction of motion

SIGNS

Upward motion is (+)
Downward motion is (-)

Motion to the right (+)
Motion to the left (-)

Exercise files

Week 1_Mechanics

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2020-2021 Academic session

Question 1

A motorbike joins a motorway travelling at 10m/s and increases speed to 30m/s with a constant acceleration of 1.25m/s along the straight road. How much time does this take and how far does the bike travel in this time?

SIGNS

Upward motion is (+)
Downward motion is (-)

What information has been provided

$$initial\ velocity\ (u) = 10m/s$$

Question 1 **Type of Motion: Straight - horizontal**

A motorbike joins a motorway travelling at 10m/s and increases speed to 30m/s with a constant acceleration of 1.25m/s^2 along the straight road. How much time does this take and how far does the bike travel in this time?

Given data	**Find?**
u= 10m/s	t (s)
v= 30m/s	s (m)
a= 1.25m/s^2	

$$v = u + at$$

$$30 = 10 + 1.25t$$

$$20 = 1.25t$$

$$t = 16s$$

SUVAT Equations

$$s = ut + \frac{1}{2}at^2$$

$$s = vt - \frac{1}{2}at^2$$

$$\boxed{v = u + at}$$

$$v^2 = u^2 + 2as$$

$$s = \left(\frac{u+v}{2}\right).t$$

Which equation connects, u, v, a and t?

Given data

u= 10m/s
v= 30m/s
a= 1.25m/s^2
t= 16s

Find?

s (m)

Which equation connects, u, v, a, s and t?

$$s = \left(\frac{u+v}{2}\right).t$$

$$s = \left(\frac{10+30}{2}\right).16$$

$$s = 320m$$

SUVAT Equations

$$s = ut + \frac{1}{2}at^2$$

$$s = vt - \frac{1}{2}at^2$$

$$v = u + at$$

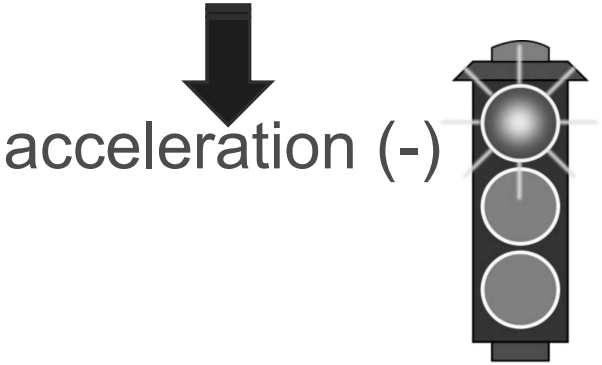
$$v^2 = u^2 + 2as$$

$$\boxed{s = \left(\frac{u+v}{2}\right).t}$$

Question 2

Type of Motion: Straight - horizontal

A driver of a car travelling along a straight road sees that the traffic lights, 40m away have turned to red. Given that after 4 seconds the car stops exactly at the traffic lights. What is the deceleration of the car?



Find?

a ($-m/s^2$)

Given data

s= 40m
v= 0m/s
t= 4s

Given data

s= 40m
v= 0m/s
t= 4s

Find?

a (-m/s^2)

Which equation connects, s, v, t, and a?

$$s = vt - \frac{1}{2}at^2$$

$$40 = (0\ x\ 4) - \tfrac{1}{2}(a\ x\ 4^2)$$

$$40 = -8a$$

$$a = -5ms^{-2}$$

SUVAT Equations

$$s = ut + \frac{1}{2}at^2$$

$$\boxed{s = vt - \frac{1}{2}at^2}$$

$$v = u + at$$

$$v^2 = u^2 + 2as$$

$$s = \left(\frac{u+v}{2}\right).t$$

Summary of key points

- ✓ A particle slowing down has a negative acceleration. This is called deceleration.
- ✓ Make sure all units are in their base S.I Units before substituting values into the SUVAT formula.
- ✓ There are five equations of motion also known as the SUVAT equations.